APPENDIX SES2.2

PIPELINE RISK ASSESSMENT

PINS document reference: 14.6.2.2

CONTENTS

TABLES

FIGURES

APPENDICES

1. Introduction and background

1.1 The Development Consent Order (DCO) application for the proposed western extension to the East Northants Resource Management Facility (ENRMF) was accepted for examination by the Planning Inspectorate on 24 September 2021.

1.2 Prior to the submission of the DCO application discussions were undertaken with the statutory undertakers whose apparatus cross the proposed western extension and standoffs were agreed with the statutory undertakers prior to the finalisation of the design of the proposed development and submission of the application. The utilities which cross the proposed western extension area of the application site include two parallel water pipes operated by Anglian Water as shown on Figure PRA1.

1.3 The details of the development location and design are set out in the application documents, including in particular the Environmental Statement (document reference 5.2 [APP-049]), and are not repeated in this document other than where reference to detail is necessary to assist in the presentation of assessments.

1.4 The agreed standoffs for the water mains were incorporated into the site design. The site design includes a 7m standoff from each of the water mains. The standoff distance is set out in Table DEC B1 of Appendix DEC B in the DCO Environmental Commitments (document reference 6.5 [APP-110]) for boundaries H and I as 7m from the water pipeline to the boundary fencing for each adjacent phase. The landfill excavation limit will be at a minimum 2.5m standoff from the fencing therefore in the design submitted with the application there is a total distance of 9.5m from the outside edge of each pipeline to the landfill excavation limit.

1.5 It is proposed that a diverted electricity cable will be located in a trench along the same route as the water pipelines. For the purposes of this risk assessment process the presence of the proposed diverted electricity cable in the same area as the water pipes is ignored as it is considered that the presence of any diverted electricity cable can be determined following the conclusion of this risk assessment process for the water pipes only.

1.6 Following continued engagement with Anglian Water since the submission of the DCO application Anglian Water first raised concerns in March 2022 with respect to the proposed standoff distances. The concerns of Anglian Water are set out in the

'Proof of Evidence' submitted by the Chief Engineer at Anglian Water dated 13 April 2022 [REP4-013] submitted to the examination at Deadline 4 (13 April 2022) and in the 'Statement' dated 11 May 2022 [REP5-011] submitted to the examination at Deadline 5 (11 May 2022).

1.7 In this report the concerns identified by Anglian Water in their April and May 2022 submissions are identified and addressed through an assessment of the potential risks presented by each scenario. The approach to identifying and addressing the concerns is explained in Section 3 of this report.

2. Information regarding the water pipelines

2.1 The water pipelines convey potable water for human consumption from Wing Water Treatment Works to supply part of Peterborough. The water supply previously was conveyed by a single pipe along the approximate route shown by the black line on a plan provided in the Anglian Water April 2022 ‘Proof of Evidence’ (the April PoE) which is reproduced below.

Plan of the Mains

2.2 The water pipes along the previous route (the black line in the plan above) comprised only a single pipe and the pipe was diverted and replaced with two pipes in around 2000 when the original landfill operations in the current ENRMF site were developed. The previous diversion took place as the landfill in Phases 1 to 11 (the current landfill site) was designed to fill the area in which the water pipe was formerly located as the site could not be designed in a practical way to stand away from the pipe. This diversion took place before Augean took over the operation of the facility. The diverted pipeline and the new, second pipeline which was added (to increase the level of resilience and increase capacity) are located approximately 15m to 20m to the south of the excavation boundary of the current site which is designed to the same principles and filled with the same wastes as proposed for the western extension area. A gas pipeline runs parallel to, and approximately 4m to the south of the southern water pipeline. The route of the pipelines through the western extension area in the natural ground between two separate areas of landfilling and a cross section through the location showing the landfill cells constructed in the adjacent landfill phases are shown on Figure PRA1.

2.3 The details of the construction of the diverted pipelines have been requested from Anglian Water and at the time of finalisation of this report the as-built construction details have not been located by Anglian Water and provided to Augean. Some details regarding the construction of the pipelines have been provided by Anglian Water in the April PoE and during subsequent discussions with Augean on 6 April and 9 May 2022. The Applicant's current understanding of the construction details are summarised below based on the information available to them.

2.4 The pipes are understood to be formed of steel each at a diameter of 800mm. The distance between the centres of the two pipes is reported as approximately 5m. The depth of the pipes is not certain but it is understood that the tops of the pipes are approximately 1.2m below the ground level. The pipe bedding is likely to be Type S1 aggregate fill to half or two thirds the diameter of the pipe covered with backfill of excavated material.

2.5 The pipes are gravity fed water mains with flow (un-boosted) driven by the reservoir pressure up stream. Anglian Water have stated that flow is likely to be at 1m^3/s at a pressure of 8bar, although as explained in the pipeline engineering assessment presented at Appendix SES2.2 (document reference 14.6.2.2) the pressure may be lower than this. We are informed that there is no pressure monitoring in the pipes, the system is designed to compensate for any loss in pressure through leaks.

2.6 The nearest isolation valves are 1km for the southern pipe and 5km for the northern pipe from the boundary of the site but their locations have not yet been clarified. It has been suggested by Anglian Water that it could take up to 4 hours for isolation following a failure of the pipe.

2.7 Anglian Water guidance on appropriate standoff distances for development near water pipes[1] is provided online and a copy was provided as Document reference 12.2.8.1. [REP5-006]. It is reasonable to assume that the guidance is based on Anglian Water's risk assessments and experience and therefore that the generic distances take into account factors such as potential failures and access

[1] Anglian Water's Cross Sector Infrastructure Access Statement. March 2019.

requirements for maintenance and repair. Anglian Water have been requested to provide any internal (or other) references or guidance used for the assessment of suitable standoff distances and for the prediction of pipe blowouts but no further information has been provided to date.

2.8 The generic advice presented in section 5.1 of the March 2019 Anglian Water guidance, which remains current, is summarised in the table reproduced below:

For land where no development is proposed		**For land marked for development or land use changes within the next 20 years in the local plan.**	
Pipe Size (mm)	**Easement protection required (m) (Overall distance)**	**Pipe Size (mm)**	**Easement protection required (m) (Overall distance)**
≤249	4.0	< 149	4.5
250-449	5.0	150-449	6.0
450-599	6.0	450-749	9.0
≥600	7.0	>750	12.0

Please note: *These easement widths are based on a nominal depth of cover (0.9m) to pipes. Easements may be widened where pipes are laid deeper then* [sic] *nominal depth. For example, water mains laid in peat are required to be at 1.1m depth and easements are increased proportionately*.

2.9 The total easement width included in the application design (between the fence lines) is 14m plus the distance between the 2 pipes of approximately 5m, plus the width of the pipes (1.6m) which is a total of 20.6m. An additional distance of 2.5m each side is included from the fence line to the excavation boundary for the landfill cells giving a total easement width of 25.6m. The design parameters therefore are considerably more protective than the guidance provided by Anglian Water (12m overall distance in the table above) and previously agreed by Anglian Water representatives. It was anticipated that the standoff widths would be greater than the generic distance as a result of the presence of two pipes, which is why a standoff distance is applied either side of each pipe rather than an easement width across a single pipe.

3. Development of potential risk scenarios

3.1 As a result of the concerns identified by Anglian Water in their April 2022 submission a scoping table was prepared and provided to Anglian Water on 29 April 2022 for discussion in order to agree the hazards and risks which it is perceived might arise and which need to be assessed. It is helpful to the risk assessment process to agree the scenarios (and their reasonable likelihood) at the outset so that the risk assessment process is methodical and as comprehensive as possible. The scoping table was provided to Anglian Water on 29 April 2022 but at the time of finalising this report, while discussions were held on 9 May 2022, no direct feedback has been provided to Augean on the scope or proposals for the risk assessment. In the absence of confirmed information on construction details, reasonable worst case assumptions have been made in the risk assessments. The scoping table of hazards and risks for assessment is provided at Table PRA1.

3.2 The situations for which the hazards and potential risks need to be considered and which are set out in Table PRA1 are divided into the following categories:

- physical/structural safety concerns under normal circumstances,
- physical/structural safety concerns under abnormal circumstances (ie following pipe failure rather than as a result of a small leak),
- access needs under normal circumstances,
- access needs under abnormal circumstances (ie following pipe failure rather than as a result of a small leak),
- contamination concerns/access under normal circumstances, and what potential exposure pathway is of concern
- contamination concerns/access under abnormal circumstances (ie following pipe failure), and what potential exposure pathway is of concern.

3.3 The landfill development in the adjacent areas will take place over a number of stages; each of the hazards and risks identified in Table PRA1 are considered for each of the following development stages as shown in Figure PRA2.

A. Pre-development;

B. Operational excavation and construction stage;

C. Operational waste placement (below ground) stage;

D. Operational waste placement (above ground) stage; and

E. Post restoration period.

3.4 As part of the risk assessment process, avoidance and/or mitigation measures which may reduce the probability that a risk scenario will occur or the magnitude or effect of the consequences of a risk scenario have been identified for consideration.

3.5 It is proposed that a diverted electricity cable will be located in a trench along the same route as the water pipelines. For the purposes of this risk assessment process the presence of the proposed diverted electricity cable in the same area as the water pipes is ignored as it is considered that the presence of any diverted electricity cable can be determined following the conclusion of this risk assessment process for the water pipes only.

3.6 In Appendix DECB of the DCO Environmental Commitments document (document reference 6.5 [APP-110]) it is stated that there will be a 3.5m standoff from the water pipeline to the diverted electricity cable and a 3.5m distance to the fencing from the diverted electricity cable.

3.7 It can be seen from the hazards and risks to be assessed as set out methodically in Table PRA1 that there are a number of key risk scenarios that arise and which are consistent across a number of the situations and development stages identified above. These are grouped together in Table PRA2 and identify the assessments necessary of the potential risks presented by each key risk scenario. The key risk scenario information in Table PRA2 was provided to Anglian Water on 29 April 2022 for consideration and comment however, while discussions were held on 9 May 2022, at the time of finalising this report there has been no direct feedback on the key risk scenarios identified.

3.8 Each of the key risk scenarios have been subject to assessments which are presented in this report as follows:

- The potential impact on the structural integrity of the pipes as a result of the landfill operations is considered in Section 4.

  - Stability of the landfill slopes (section 4.2)
  - Potential effects resulting from changes in ground pressures (section 4.3)
  - Potential for effects as a result of increased water flow in pipe bedding (section 4.4)
  - Pipeline crossing points (section 4.5)

- The potential for and consequences of leaks and failures are considered in Section 5.

  - Possible size of a crater formed as a result of catastrophic failure (section 5.2)
  - Consequence of the discharge of water to the landfill (section 5.3)

- The potential for contamination of water in the pipes is considered in Section 6.

  - Potential for contamination when the pipe is intact (section 6.2)
  - Potential for contamination during repair following pipe failure (section 6.4)
  - Potential for the migration of contaminants from the waste into the pipe bedding (section 6.4)

- Access to the pipelines for maintenance and repair is considered in Section 7.

  - Space required to carry out repairs (section 7.2)
  - Restrictions to access as a result of inundation along the pipe route (section 7.5)

- The conclusions of each of the assessments are summarised in Section 8 and in Table PRA2.

4. Potential impact on the structural integrity of the pipes as a result of the landfill operations

4.1 Introduction

4.1.1 In this section of the report assessments are carried out of the key risk scenarios identified in the following sections of Table PRA2:

- 2. Pipe Intact: Impact on structural integrity of the pipes as a result of landfill excavation and filling. Development stages B, C D.

- 5. Pipe Intact: Surface water run off causing increased inundation around pipelines increasing the potential for erosion of the pipes. Development stage E.

4.1.2 As shown on Figures PRA1 and PRA2, it is proposed that landfill phases will be constructed either side of the pipeline route. Each phase is excavated, engineered and filled in a relatively short time period (typically no more than two to three years) therefore no excavated slopes will remain open and unsupported for more than a few months. Once the engineered landfill cell is filled to above the ground level there will be no unsupported excavated slopes and the waste is placed to achieve the final approved levels followed by the placement of an engineered cap and restoration soils. Due to the phasing of the landfill operations it is unlikely that unsupported excavated slopes would be present either side of the pipeline route at the same time.

4.2 Stability of the landfill slopes

4.2.1 As described in Section 5 of the Environmental Statement (document reference 5.2 [APP-049]) the landfill design and geotechnical risk assessments are submitted to the Environment Agency for review and approval as part of the Environmental Permit application. The detailed design of each phase together with a Construction Quality Assurance Plan are submitted to the Environment Agency for approval prior to the commencement of construction of each phase. The excavation and construction works then are subject to Construction Quality Assurance with a Verification Report submitted to the Environment Agency for approval before waste can be placed in that phase.

4.2.2 In accordance with Environment Agency guidance the excavated slope designs are assessed to verify that they have a factor of safety of greater than 1.3 while they are open. The slopes do not stand open for long as they are lined with engineered clay and geosynthetic materials before being backfilled soon after construction. The excavated slopes are assessed to have factors of safety of 1.4 while they are open, which is greater than the target factor of safety of 1.3, and this factor of safety will increase rapidly as the slopes are lined and then filled, becoming fully supported and therefore unable to fail once waste reaches the level of the adjacent ground. The slopes are monitored during the period that they are open as this is a requirement of the Stability Risk Assessment (SRA) for the Environmental Permit for the hazardous waste landfill site (annual monitoring is referenced in paragraph 7.1 of the SRA [REP2-010]). The stability of the slopes does not rely on the presence of unexcavated ground or filled phases in the landfill phases on the opposite side of the pipeline route, which will be at least approximately 25.6m away at the closest point.

4.2.3 The gradients of the above ground level waste slopes and the restored landfill slopes also are subject to stability risk assessment and are designed to a factor of safety of 1.4.

4.2.4 During the slope excavation and lining and during the construction of the low permeability capping layer there is full time supervision on site of the works by independent Quality Assurance engineers in accordance with the Construction Quality Assurance (CQA) Plan approved by the Environment Agency. This monitoring is specified through the Environmental Permit for the hazardous waste landfill site.

4.2.5 During the filling of the landfill phases and the restoration of the slopes the stability and integrity of the slopes and lining system are monitored by Augean in accordance with the site operational procedures and Environmental Permit requirements.

4.2.6 Based on the proposed design of the landfill phases, there is a distance of 9.5m between the edge of the excavation and each of the water pipes. As a result of the factors of safety incorporated into the landfill design, the CQA implemented to confirm the landfill is constructed in accordance with the design, the ongoing monitoring of the slopes in accordance with the Environmental Permit and the distance from the edge of the excavation to the pipes there is a negligible potential for the slopes of the adjacent landfill phases to fail and to result in instability of or damage to the water pipes.

4.3 Potential effects resulting from changes in ground pressures

4.3.1 Anglian Water have raised concerns in the April PoE regarding the '…*heave and contraction of exposed highly shrinkable clays of this region and the impact of differential loading to the stability of the corridor containing the Mains*.' [REP4-013] It is understood that this concern relates to the potential for the release of pressure resulting from the excavation of the landfill voids and the potential for the increase of pressure as a result of the placement of waste above ground level to affect the ground pressures around the pipelines potentially leading to increased instability of the pipes.

4.3.2 Changes in ground pressures caused by the excavation and filling of the landfill reduce quickly as distance from the pipeline increases and these can be quantified based on the ground conditions, pipeline surround and nature of the pipeline. An assessment has been carried out by a specialist pipeline engineer and is presented in Section 6 of the report at Appendix SES2.3 (document reference 14.6.2.3).

4.3.3 It is stated in the report at Appendix SES2.3 that when designing new pipelines, it is generally accepted that when the trench width is greater than 4.3 multiplied by the pipe outside diameter, the effect of the native soil to the sides of the pipe are ignored (see British Standard 9295 (2020) section 7.2.5). The diameter of the pipes is 0.8m which, when multiplied by 4.3 is 3.44m. The total design distance of 9.5m from each pipe to the closest edge of the landfill is therefore well beyond the distance of 3.44m at which it is stated in the British Standard that any effects of native soils on the pipelines (which would include the effects of any changes in those soils) need to be considered.

4.3.4 It is stated in Section 4.6 of British Standard 9295 that "*the zone of soil which has a structural influence on the buried pipe typically extends between one and two diameters from the pipe wall in all directions*". The diameter of the pipes is 0.8m which, when multiplied by 2 is 1.6m. The total design distance of 9.5m from each pipe to the closest edge of the landfill is therefore well beyond the distance of 1.6m at which it is stated in the British Standard that the soil has a structural influence on the buried pipe.

4.3.5 With regard to the nature of the clay at the site, this is well known and well understood. The clay has been used at the site for decades and provides a robust engineering material with which to construct the containment systems for the landfill site. The clay is typically stiff with a very low permeability which means it is not susceptible to changes in moisture content which could allow it to shrink. The existing situation is that the current pipeline is already surrounded by these clays.

4.3.6 Augean has extensive information and experience of the geotechnical properties of the clay material around and under the pipelines so it is not anticipated that further site investigation is needed.

4.3.7 It is concluded that the original design stand-off dimension proposed by Augean of 7m from the fence line and a total of 9.5m from the landfill excavation is more than adequate in all cases to make sure that the pipelines will be unaffected by any excavations taking place, and the presence of the excavation activity will not increase the likelihood of pipe failure from the shrink/swell effects associated with the excavation of the clay.

4.4 Potential for effects as a result of increased water flow in pipe bedding

4.4.1 It is understood that Anglian Water may be concerned that surface water run-off from the site surface water management system will result in increased inundation of the pipe bedding around the pipeline resulting in increased corrosion. For the reasons set out below it is considered that this concern is unfounded.

4.4.2 As described in the Surface Water Management Plan (SWMP) (Appendix ES18.2, document reference 5.4.18.2 [APP-095]) surface water run-off from the landfill areas while the phases are operational will be collected and contained within the active landfill phases. Following site restoration clean surface water run-off will be collected in interceptor ditches and directed away from the route of the pipelines as shown in the SWMP.

4.4.3 The water retention lagoons or swales which are an integral feature of the SWMP for the restored site will be dry for all but a short time immediately following storm events. They would not fulfil their function as attenuation basins unless they remain dry to provide the freeboard needed following rainfall events. The runoff released from the attenuation basins will follow the routes of the current field drainage to mimic the current discharge patterns therefore the potential for an increase in flow in the bedding for the mains pipes is negligible. In practice the interceptor ditches, retention lagoons or swales will prevent surface water run off draining over the pipelines and ensure that it is drained and discharged away from the pipelines.

4.4.4 It is considered that as a result of the surface water management controls which will be implemented there is a negligible risk that there will be increased inundation of the pipe bedding around the pipeline resulting in increased corrosion of the pipes.

4.4.5 Notwithstanding the conclusion above, it is understood that it is possible to monitor the level of water around the pipeline in the pipeline bedding. Monitoring of the water levels around the bedding could be carried out in the anticipated 8 to 10 years prior to landfilling near to the pipeline and following landfilling during the operational period in the adjacent phases to confirm the above conclusion. If additional surface water drainage management measures are identified as necessary they can be implemented.

4.4.6 As a result of the proposals in the Surface Water Management Plan it is considered that any monitoring of the water flow in the pipeline bedding is not necessary as mitigation as it is not required to control environmental impacts or effects. The option of such monitoring is suggested by the Applicant to provide additional comfort to Anglian Water in order to reach agreement on a sensible standoff distance. Accordingly any commitment relating to monitoring which might be undertaken will be secured through the Protective Provisions with Anglian Water.

4.5 Pipeline crossing points

4.5.1 The design of a crossing point over pipelines typically and routinely is carried out as a bespoke design for the specific circumstances which are agreed between the pipeline operator and the developer prior to construction. Crossing points for the water pipes will not be needed until work commences in the southern area of the proposed western extension (Phase 15).

4.5.2 An assessment of the potential loading on the pipes resulting from crossing by the heaviest types of plant which are likely to be used in the proposed development has been carried out by a specialist pipeline engineer and is presented in section 4 of the report at Appendix SES2.3 (document reference 14.6.2.3). As the depth of the pipelines has not been confirmed by Anglian Water at this stage the assessment of the effect of loadings from plant crossing the pipes is carried out based on an assumed worst case cover depth of 1.2m and an assumed cover depth of 3m. The results show that the pipelines comfortably pass the assessments and have a factor of safety against buckling significantly greater than the required value of 2 in all loading cases which are considered including where it is assumed that the original pipe wall thickness may have been reduced.

4.5.3 Notwithstanding the conclusions above, it is accepted practice that designated crossing points will be constructed to allow vehicular movement across the pipelines in order to ensure that the ground surface doesn't deteriorate. Rutting of the ground surface could result in wheel loads becoming unacceptably close to the pipeline crowns, and this should be avoided therefore the main purpose of the designed crossing points will be to maintain the condition of the ground surface.

4.5.4 It is concluded that a suitable crossing over the pipelines can be constructed readily, using standard methods that will protect the integrity of the pipelines. A specification for design of the crossing will be discussed and agreed with Anglian Water. This is allowed for in the Anglian Water preferred Protective Provisions and Anglian Water have stated [REP4-014] that they do not require a separate crossing agreement.

5 Potential for and consequences of leaks and failures

5.1 Introduction

5.1.1 In this section of the report assessments are carried out of the key risk scenarios identified in the following sections of Table PRA2:

● 6. Pipe Failed: Catastrophic failure resulting in a crater affecting the integrity of the landfill. Development stages C, D, E.

● 7. Pipe Failed: Failure resulting in water discharge to the landfilled waste. Development stages C, D.

5.1.2 It is noted in Section 2 of the report at Appendix SES2.3 (document reference 14.6.2.3) that if failures of the steel pipe body occur, they are most often associated with through-wall corrosion, rather than a catastrophic burst that can be seen in more brittle materials, such as cast iron. More serious issues can occur at the welded joints, if these have not been correctly executed and supervised, or if, during construction, pipe alignments are not correct. It is understood that there have been no failures of the pipelines crossing the area of the proposed western extension to the ENRMF site or where the pipeline runs adjacent to the existing site, although it is understood from Anglian Water that there has been prior leak of this pipeline recorded in a 'proceeding' section of one of the pipes which we understand is a location upstream of the development site.

5.1.3 It is stated at paragraphs 6 and 7 of the Statement of Mark Frogatt dated 11 May 2022 [REP5-011] that the water supply networks are assessed in accordance with the Anglian Water established risk model which takes account of the age, pressure, population served and ground conditions to determine a risk factor (or likelihood of) failure within a given time period. The results of the analysis are presented in the plan provided with the 11 May 2022 Statement and show that for a main of this type there is a low risk of failure.

5.1.4 It is accepted by all parties that the greatest potential type of failure, if there is any failure at all, would be a leak. If a leak is undetected and unresolved, there is the potential, albeit very low, that the weakness in the pipe could increase and that a catastrophic failure could occur. In addition, small leaks can develop and lead to loosening of the pipe embedment resulting in potential loss of support locally to the pipeline. Ultimately, this could in a worst case scenario lead to a more catastrophic failure. It is understood that due to the method of operation of the pipeline, in which the flow is not pumped but is driven by gravity feed from the Wing Water Treatment Works, any loss in pressure resulting from a leak is compensated for by increased gravity flow therefore it is uncertain that a leak would be detected by a loss of pressure in the pipeline.

5.1.5 Notwithstanding the low probability of a leak and the extremely low probability of a catastrophic failure of the pipes, the low risks of serious failure could be reduced further by the provision of monitoring at the site. It is agreed by Anglian Water that monitoring (eg acoustic loggers) could provide for detection at the site of any leaks so that early attention can be paid to carrying out repairs. Early identification of faults would allow repairs to be carried out to reduce further the risk of additional weakening of the structures and consequent catastrophic failure.

5.1.6 As a result of the low probability of failure and the lack of evidence based on the risk assessments presented below that the proposals could result in any increased risk of failure of the pipelines, it is considered that any additional monitoring for leaks is not necessary as mitigation as it is not required to control environmental impacts or effects of the proposed development. The option of such monitoring is suggested by the Applicant to provide additional comfort to Anglian Water in order to reach agreement on a sensible standoff distance. Accordingly any commitment relating to monitoring which might be undertaken will be secured through the Protective Provisions with Anglian Water.

5.2 Possible size of a crater formed as a result of catastrophic failure

5.2.1 As explained above, the likelihood of a catastrophic failure and the formation of a crater is extremely low. Nevertheless an assessment has been carried out by a specialist pipeline engineer of the likely size of a crater, if one was formed.

5.2.2 The assessment is presented in Section 5 of the report at Appendix SES2.3 (document reference 14.6.2.3) where the potential size of crater has been calculated for a number of different burial depths and assuming a worst-case scenario of both pipelines failing. It is calculated that if both pipes failed and a worst case burial depth of the pipes is assumed of 3m, a crater diameter of approximately 12.6m could be formed. The distance to the side of each pipe is calculated as 3.41m if the pipe is at a depth of 3m

(Dimension A in Figure 4 in the report at Appendix SES2.3 (document reference 14.6.2.3)). It is understood, but unconfirmed, that the pipeline is probably installed at a cover depth of 1.2m so the calculation is particularly conservative. A calculation also has been carried out for an assumed pipe depth of 1.5m which results in a calculated crater diameter of 9.63m which is a calculated distance of 1.91m from each pipe (Dimension A in Figure 4 in the report at Appendix SES2.3 (document reference 14.6.2.3)).

5.2.3 This worst case calculation shows that at the current design standoff distances to the excavation boundary of 9.5m and to the fence line boundary of 7m, such an extremely unlikely, worst case catastrophic failure would not affect the integrity of the landfill engineering. There would remain a significant buffer distance between the extent of any ground disturbance resulting from the failure and the landfill structure.

5.3 Consequence of the discharge of water to the landfill

5.3.1 As explained above, the likelihood of a catastrophic failure and therefore the release of all the water from the pipeline into the engineered landfill void is extremely low. Water inundation of the excavations is only possible while the excavations are open which typically would be for no more than two to three years. As part of the operational surface water management drainage ditches are installed along the outside of the operational areas to divert surface water runoff away from the landfill areas. If necessary, cut off bunds also could be constructed. The design of the operational surface water management measures will be agreed with the Environment Agency as part of the operations the subject of the Environmental Permit.

5.3.2 The volume of water which might be released from a burst water main has been estimated based on information provided by Anglian Water in the Statement dated 11 May 2022 [REP5-011]. The flow quoted in the Statement is an average of 300litres per second ($0.3m^3/s$) which would change to approximately 1000litres per second ($1m^3/s$) from a single pipe in the event of a rupture, presumably as a result of increased flow in response to water hence pressure loss through the leak. Augean was informed by Anglian Water at a meeting on 5 April 2022 that it would take approximately 4 hours for the flow to be minimised after a catastrophic failure in the pipe. It is noted in the report at Appendix SES2.3 (paragraph 5.3) (document reference 14.6.2.3) that it is likely that the flow in the pipes would be less as the pressure is expected to be less than that quoted, however the flows provided by Anglian Water are used as a worst case.

5.3.3 The estimate is based on the assumption that all water released from the pipe would enter one adjacent phase of the landfill site, however in reality much of the water released would flow away from the landfill area on the surface or through the soils or pipe bedding. A flow of water at approximately 1m^3 per second for 4 hours would result in the release of 14,400m^3 of water from one pipe. It is calculated based on the smaller of the adjacent phases (Phase 18) that this release of water, if it were to all enter Phase 18, would result in an excess depth of leachate of approximately 1.5m.

5.3.4 In an absolute worst case scenario if both pipes were to fail and all the water entered the same phase (which is highly unlikely) it is calculated that this would result in an increased depth of leachate of approximately 3m. This increase is manageable and would be contained within the engineered containment system and does not pose an increase in the environmental risk as the excess depth of leachate would be present only for a relatively short time prior to removal. The increased depth of leachate would not represent the introduction of more contaminants, simply an increased depth of leachate with the concentration of contaminants present in the original leachate diluted by the additional water from the pipes. A short term exceedance of leachate levels set in the Environmental Permit is not uncommon for landfill sites and is unlikely to result in an unacceptable environmental impact. This conclusion regarding a short term increase in leachate levels was agreed by the Environment Agency during the Issue Specific Hearing on 29 March 2022.

5.3.5 It is concluded that in the highly unlikely event that if all the water from two failed pipes entered the adjacent landfill void, there would be no significant unacceptable environmental consequences.

6 Potential for contamination of water in the pipes

6.1 Introduction

6.1.1 In this section of the report assessments are carried out of the key risk scenarios identified in the following sections of Table PRA2:

- 3. Pipe Intact: Contaminant migration from the landfill below ground to the pipeline surrounds. Development stages C, D, E.

- 4. Pipe Intact: Contaminant run-off to the pipeline surrounds. Development stages C, D.

- 9. Pipe Failed: Risk of contamination of surrounding ground will enter the water supply. Development stages C, D, E.

6.2 Potential for contamination when the pipe is intact

6.2.1 A cross section through the route of the pipelines showing the construction of the adjacent landfill phases is shown on Figure PRA1.

6.2.2 The landfill is engineered in order to minimise the potential for the migration of contaminants beyond the site. The design for the containment basal and perimeter engineering comprises a minimum of a 1m thickness of clay at a permeability of $1x10^{-9}$m/s and a 2mm thickness of HDPE at a permeability of $1x10^{-14}$m/s. The landfill and the pipeline are situated within in-situ clay with a vertical permeability of 1.9×10^{-10}m/s to 8.4×10^{-12}m/s with a geometric mean of 2.6×10^{-11}m/s (based on 5 samples of glacial till from the site). The justification for the site design submitted with the Environmental Permit variation application includes a Hydrogeological Risk Assessment which demonstrates that the containment engineering is appropriate to make sure that there is no migration of contaminants from the landfill to the surrounding environment that would have a significant adverse effect on the water quality in the vicinity of the site. Accordingly, even if the water pipes were adjacent to the level of the leachate in the landfill phases, there would be no significant contamination of the ground outside the landfill site. Even if there were contamination present outside the landfill site, there is no conceivable pathway for contaminants to enter the water which is present in the pipeline under pressure.

6.2.3 Notwithstanding these reasons, as shown in Figure PRA1, the contaminants in the leachate in the contained landfill site are maintained at a level no greater than 1m above the base of the site which is at least 7m below the pipelines. Groundwater is at least 8m below the base of the site in the vicinity of the pipelines therefore there is no conceivable means by which mobile contaminants could even be adjacent to the pipes.

6.2.4 It has been suggested by Anglian Water that the low level radioactive waste (LLW) which it is proposed will be accepted at the site might affect or be perceived to affect the quality of the water in the pipelines. As for non-radioactive contaminants in leachate, there is no conceivable means by which mobile radioactive contaminants could even be adjacent to the water pipes. Gamma radiation from LLW is attenuated through the landfill cell walls and the clay and soil. In addition it is a condition of the current radioactive wate landfill permit and it is likely to be a condition in the Environmental Permit for the permit for the proposed western extension that no LLW is deposited within 2m of the landfill boundary engineering. Accordingly gamma radiation from the LLW will not affect the properties of the water in the pipelines.

6.2.5 As the wastes deposited in the landfill will have limited gas generating potential the generation of gases or vapours under pressure at the site is not anticipated. Gas concentrations and pressures are monitored under the Environmental Permit. If active extraction and management becomes necessary it will be implemented in accordance with the Environmental Permit. As no or only low levels and quantities of gas are likely to be generated in the site there is no conceivable means by which significant concentrations of gas could even be adjacent to the pipes. Even if there were landfill gas present outside the landfill site, there is no conceivable pathway for the gas components to enter the water which is present in the pipeline under pressure.

6.2.6 It is concluded that there is no conceivable pathway by which contaminants in the landfill site could migrate to and affect the quality of the water in the pipelines.

6.3 Potential for contamination during repair following pipe failure

6.3.1 In order to understand the concerns expressed by Anglian Water that contaminants might enter the water in the pipeline during repairs following failures in the pipes, the procedures for the management of leaks and catastrophic failures of water pipes have been requested from Anglian Water to assist in the risk assessment process however this has not been provided at the time of finalisation of this report.

6.3.2 It is stated by Anglian Water at paragraph 11 of the Statement dated 11 May 2022 [REP5-011] that where a leak of water from the pipes is identified, the response is to maintain pressure and flow in the pipes so that there is no risk of external water being introduced into the mains and potentially contaminating them. Accordingly, even if contaminated water was present in the vicinity of the pipes, which as explained above it would not be, there is no risk that the contaminated water present outside the pipes would enter the water inside the pipes.

6.3.3 It is conceivable that if the flow of water in a pipe is stopped so that a repair can be carried out, there would be a risk that contaminants present in the ground adjacent to the pipes could be introduced into the pipes as the repairs are carried out. It would be expected that standard repair procedures include requirements to carry out repairs in a manner which minimises the potential for soil and any associated contaminants from entering pipes during any repair and these measures also would minimise the risk of contaminants entering the pipes at this time. It is explained in section 7 of the report presented at Appendix SES2.3 (document reference 14.6.2.3) that it is standard practice during the repair of water pipes that when a repair is undertaken, every effort is made to ensure the cleanliness of the pipeline is not compromised. Water and soil debris are kept away from the internal surfaces of the existing pipeline, the repair piece and couplings. Anglian Water will have strict protocols in place regarding mains repair to ensure no contamination of the water occurs, and typically this will include spraying repair pieces and fittings with chlorous acid or similar, flushing of the main and bacteriological sampling to demonstrate water hygiene compliance. However, as explained above, there is no conceivable pathway by which contaminants associated with the landfill would be present in the ground around the pipes and therefore risk being introduced into the pipes during pipe repairs.

6.4 Potential for the migration of contaminants from the waste into the pipe bedding

6.4.1 Concern has been raised by Anglian Water that there is the potential for the migration of contaminants from the waste into the pipe bedding and onward migration of the contaminants to groundwater or surface water.

6.4.2 During the operational phase of the landfill site, surface water run-off from the landfill areas will be collected and contained within the active landfill phases in accordance with the principles in the operational surface water management plan which will be implemented through the Environmental Permit. Following completion of landfilling in each phase, a low permeability capping layer is constructed and keyed-in to the perimeter containment system to provide a continuous low permeability seal. The infiltration of rainfall is minimised by the low permeability cap and any residual leachate that is formed in the waste drains to the leachate collection and management system in the base of the site.

6.4.3 As explained above and shown in the cross section at Figure PRA1, leachate levels are maintained no greater than 1m above the base of the landfill site which is at least 7m below the level of the pipelines therefore there is no identified below ground pathway for the contaminants in the landfill site to migrate to the bedding around the pipelines. In addition to the perimeter engineered containment a drainage layer (a geocomposite with a drainage core) will be installed to provide a leachate drainage blanket up the inner side slopes of the engineered liner to direct any perched levels of leachate in the landfill to the basal leachate collection blanket.

6.4.4 The standards of design, construction and operation of the landfill site and the requirements of the Environmental Permit for the facility are to make sure that there is no contamination of the ground or water around the landfill. Accordingly there is no risk that contaminants from the landfill will enter the bedding around the pipes and result in contamination of surface water or groundwater quality elsewhere.

7 Access to the pipelines for maintenance and repair

7.1 Introduction

7.1.1 In this section of the report assessments are carried out of the key risk scenarios identified in the following sections of Table PRA2:

- 1. Pipe Intact and Pipe Failed: Access for maintenance and repairs. All development stages.

- 8. Pipe Failed: Failure resulting in water inundation along the pipeline area preventing access. Development stages C, D, E.

7.2 The access space required to carry out repairs

7.2.1 It is accepted by all that the standoff provided either side of the water pipes needs to allow for access to and repair of the pipes if it becomes necessary. As explained in section 5 above, the potential for leaks is low and for failures is extremely low and therefore the probability that repairs will need to be carried out also is low. Consideration has been given to the space needed to effect repairs but these do not need to be based on the maximum area needed as it will not be necessary in practice for all activities associated with emergency repairs to be restricted to the pipeline route between the fence lines. For example, the placement of materials and stockpiles can be spaced along the pipe route and do not need to be laid out in the same area; alternatively, the fences can be removed temporarily and the restored slopes of the landfill (once they are in place) can be used for temporary stockpile and material placement during the repair process. Laydown areas do not need to be accommodated in the pipeline route between the landfill areas as there is open agricultural land at the eastern end of the corridor which could be utilised. In addition, as explained in the report at Appendix SES2.3 (document reference 14.6.2.3), the calculations show that the pipes are able to withstand crossing by plant and therefore access can be obtained by most plant if not all plant from the other side of the pipe corridor with no additional precautions or with standard available and routinely used temporary roadway crossing sections. Safe access could also be available through the landfill site (as used by road going waste delivery vehicles on a routine and daily basis) and arranged by Augean other than during the limited period when the engineered liner has been constructed on the slope where access is sought and before waste has been placed.

7.2.2 Anglian Water state at paragraph 22 of the Statement dated 11 May 2022 [REP5-011] that the following distances are necessary to provide access for repairs and the distances suggested by the pipeline engineer in Section 7 of the report at Appendix SES2.3 (document reference 14.6.2.3) also are presented below:

Activity	**Width considered necessary by Anglian Water**	**Width considered necessary**
Tracking room for excavator	4m + 2m for slewing = 6m It is considered that the slewing distance can overlap with other activities and need not be in addition to them.	3.6m + passage = 5m
Edge of passage space	1m minimum	See above
Haulage road	6m (it is considered a narrower width such as 4m would be adequate, alternatively the space used by the excavator could share the haul road and other vehicles could access the area from either side of the pipeline route)	Not included. It is considered that vehicles could access the repair area from either end of the pipeline route
Pedestrian walkway	1.5m (this could be on the restored landfill area)	Not included (this could be on the restored landfill area)

Assumed crater/working distance from the pipeline	4m	Approximately 3.5m (3.41m)
Soil stockpile and pipe laydown	Not included.	Stockpiles could be located on the restored landfill area or further along the pipeline. corridor not adjacent to the excavator working area.
Total	Suggested by Anglian Water: 18.5m	Distance considered necessary: 8.5m

7.2.3 It can be seen from the range of estimates above that there is no fixed distance which can be specified as there are a number of alternative approaches to determining how the space available will be used. Anglian Water state that they consider that an approximate distance of 20m minimum from the edge of each pipe is needed to provide adequate access for repairs and the distances set out in the table above suggest that a distance of 8.5m could be adequate as illustrated on Figure PRA3. A narrower distance of 8.5m compared with the 20m specified as 'ideal' by Anglian Water [paragraph 17, REP5-011] is set out above which can be acceptable if a more flexible approach is taken to the locations of the plant and other items needed for a repair. As noted in Section 2 of this report, the distance from the edge of the landfill excavations to the pipe is 9.5m in the proposed development as currently designed therefore, with the temporary removal of the fences during emergency repair work (if they are in place at the time), there is adequate space for carrying out repairs as shown on Figure PRA3.

7.2.4 The standoff required by other water companies for the protection of and the provision of access to their infrastructure has been reviewed and the distance from the pipeline specified by those reviewed range from 4.5m (South West Water) to 10m (Scottish

Water). The Anglian Water range of easements in their guidance (this is a total distance and not the same as a standoff) is 7m to 12m. These easement distances are not dissimilar to those estimated as necessary above.

Water Company	Diameter (mm)	Depth of cover (m)	Easement	Stand-off
South West	>601	Not specified	9m (4.5m each side of pipeline)	Not specified
Anglian	>600	0.9	7m – 12m	Not specified
Southern	800-999	1.5	Not specified	8m
	800-999	4.5	Not specified	12m
Yorkshire	>600	Not specified	6m from centreline	Not specified
Affinity	>450mm	Not specified	8m (4m from the centreline)	Not specified
Scottish	>600	Not specified	Min 10m from edge of pipeline	Not specified

***Source references**:*

https://www.southwestwater.co.uk/developer-services/water-services-and-connections/building-near-water-mains/

https://www.anglianwater.co.uk/siteassets/developers/development-services/cross-sector-infrastructure-access-statement---march-2019.pdf

https://www.southernwater.co.uk/media/3011/stand-off-distances.pdf

https://www.yorkshirewater.com/media7/2396/requirements-for-easements.pdf

https://www.affinitywater.co.uk/docs/developer/Building-Near-Pipes-Apparatus-Guide-17-04-2019-final.pdf

https://www.scottishwater.co.uk/-/media/ScottishWater/Document-Hub/Business-and-Developers/Connecting-to-our-network/All-connections-information/190718AssetPolicyStandardWaterMainsProtectionDistanceFeb16.pdf

7.2.5 It is concluded in Section 5 of this report that the probability of the need to carry out repairs is low, however adequate space should be provided to allow for access in the unlikely event that repairs are needed. Estimates for the space needed, depending on the assumptions made and the flexibility in locating the plant and items required, range from 8.5m to 20m. The period when access will be most restricted is when the landfill phases are operational and not yet capped and restored as materials cannot be stored temporarily on the landfill area during this period. If repairs are needed during this period of a few years (two to three years typically) the maximum flexibility would be needed in terms of relative positioning of the plant and items but there remains sufficient space outside the operational landfill area for access (a total of 9.5m) together with the potential for access from the other side of the water pipe corridor and from the landfill area itself.

7.2.6 It is clear that the access available for repairs is the limiting factor (ie the greatest distance) to determine the standoff from the water pipes. The distances associated with calculated crater size following catastrophic failure (see Section 5) and standoff needed so that there is no effect on the structural integrity of the pipes (see Section 4) are less (ie shorter) than those identified as necessary for repair access purposes.

7.2.7 In order to allow a wider access and materials storage corridor if needed over the longer term, the restoration design for the landfill can restrict the locations for planting of hedges to a distance from the pipelines which would allow the accommodation of stockpiles and pedestrian access on the restored area should it be needed.

7.3 Restrictions to access as a result of inundation along the pipe route

7.3.1 Anglian Water state at paragraph 20 of their 11 May 2022 Statement [REP5-011] that following catastrophic failure of the pipe the flow of water would inundate the pipeline route and restrict access for repairs as a result of the presence of deep water. It is considered that there is no justification for this concern. The pipe corridor will not form a flooded canal that restricts access and compromises stability and integrity. The ends of the proposed pipe route are open and there is no restriction to flow. The current falls of the ground levels are generally along the line of the pipeline and fall to the north west for the majority of the pipeline route, with the south eastern third falling to the south east. Water is therefore unlikely to pond in the area of the pipelines. In addition, ditches can be installed at the edges of the corridor to provide confidence regarding effective drainage if there remains any justified concern.

7.3.2 The capacity of the pipeline corridor to convey surface water issuing from a burst pipe has been calculated based on Manning's resistance equation which takes into account the dimensions, geometry and other characteristics of the corridor. For the purposes of the calculations it is assumed that the corridor comprises an open channel generally.

Calculations of the flow capacity in the pipeline corridor using Manning's resistance equation are presented at Appendix PRA1. Based on the total pipeline corridor width included in the application design between the the excavation boundary for the landfill cells of 25.6m (see paragraph 2.9) and the current falls of the ground levels along the line of the pipeline, should water accumulate in the pipeline corridor from a burst pipe, once the water reached a depth of approximately 0.15m the flow along the corridor towards the north west would be approximately the same as the flow from the burst pipe of 1m^3/s meaning that no more water would accumulate as the water would flow away at the same rate it was issuing from the pipe. Once the section of burst pipe is isolated and flow from the burst pipe is stopped, any remaining water in the area of the burst pipe will continue to flow away from the point of the pipe failure hence there will be no further accumulation of water in the area of pipe failure. Accordingly there will be no flooding of the pipeline area that will restrict access to the area for repairs.

7.3.3 The presence of surface water storm attenuation ponds or swales will not restrict access. These structures will be dry other than for short periods following storm events when they are required to hold water for subsequent release at controlled rates. The surface water management system for the restored site is designed to retain the current, pre-development, patterns of drainage and this includes the drainage patterns along the pipeline route.

8 Summary and conclusions

8.1 The utilities which cross the proposed western extension area of the application site include two parallel water pipes operated by Anglian Water. Prior to the submission of the DCO application discussions were undertaken with Anglian Water and standoffs were agreed prior to the finalisation of the design of the proposed development and submission of the application.

8.2 The agreed standoffs were incorporated into the site design which includes a 7m standoff from each of the water pipelines. The standoff distance is 7m from each water pipeline to the boundary fencing for each adjacent phase. The landfill excavation limit will be at a minimum 2.5m standoff from the fencing therefore in the design submitted with the application there is a total distance of 9.5m from each pipeline to the landfill excavation limit.

8.3 The generic advice provided by Anglian Water in a document dated March 2019 which remains current is for a total distance of 7m for land where no development is proposed and a total distance of 12m where development or land use changes are proposed. The generic standoff distances take into account risks and consequences of failure and need for access should it be necessary to carry out repairs.

8.4 The total easement width included in the application design (between the fence lines) is 14m plus the distance between the 2 pipes, which is a total of 20.6m. An additional distance of 2.5m each side is included from the fence line to the excavation boundary for the landfill cells giving a total easement width of 25.6m. The design parameters therefore are far more protective than the guidance provided by Anglian Water (12m overall distance) and previously agreed by Anglian Water representatives.

8.5 As a result of concerns identified by Anglian Water in their April 2022 submission regarding the standoff distances allowed, a risk scenario scoping exercise was carried out and the findings are presented in this report. The findings take into account the assessments carried out by a specialist pipeline engineer appointed by Augean.

8.6 An assessment has been carried out of the potential impact on the structural integrity of the pipes as a result of the landfill operations. As a result of the factors of safety incorporated into the landfill design, the Construction Quality Assurance implemented to confirm the landfill is constructed in accordance with the design, the ongoing monitoring of the slopes in accordance with the Environmental Permit and the distance from the edge of the excavation to the pipes of 9.5m, it is concluded that there is a negligible potential for the slopes of the adjacent landfill phases to fail and to result in instability of or damage to the water pipes.

8.7 Changes in ground pressures caused by the excavation and filling of the landfill reduce quickly as distance from the pipeline increases and these have been assessed based on the ground conditions, pipeline surround and nature of the pipeline. It is concluded that the original design stand-off dimension proposed by Augean of 7m from the fence line and a total of 9.5m from the landfill excavation is more than adequate in all cases to make sure that the pipelines will be unaffected by any excavations taking place, and the presence of the excavation activity will not increase the likelihood of pipe failure from the shrink/swell effects associated with the excavation of the clay.

8.8 It is considered that as a result of the surface water management controls which will be implemented there is a negligible risk that there will be increased inundation of the pipe bedding around the pipeline resulting in increased corrosion of the pipes. Notwithstanding this conclusion, monitoring can be carried out of the level of water around the pipeline in the pipeline bedding to determine if there are any significant changes over time.

8.9 It is concluded that a suitable crossing over the pipelines can be constructed readily, using standard methods that will protect the integrity of the pipelines. A specification for design of the crossing will be discussed and agreed with Anglian Water at the appropriate time.

8.10 An assessment has been carried out of the potential for and consequences of leaks and failures in the pipes. It is concluded that there is a low probability of a leak and an extremely low probability of a catastrophic failure of the pipes and the low risks of serious failure could be reduced further by the provision of leakage monitoring at the site.

8.11 The potential size of a crater which could form as a result of a catastrophic failure has been calculated for a number of different burial depths and assuming a worst-case scenario of both pipelines failing. It is calculated that if both pipes failed and the worst case burial depth of the pipes is assumed, a crater diameter of approximately 12.6m could be formed. The distance of the crater to the side of each pipe is calculated as 3.41m if the pipe is at a depth of 3m. There would remain a significant buffer distance between the extent of any ground disturbance resulting from the failure and the landfill structure which is a total distance of 9.5m from each pipe.

8.12 The consequences of the discharge of the water from a burst pipe into the landfill have been assessed. It is concluded that in the unlikely event that all the water from two failed pipes entered the adjacent landfill void, there would be no significant unacceptable environmental consequences.

8.13 An assessment has been carried out of the potential for contamination associated with the landfill operations to affect the quality of the water in the pipes. It is concluded that there is no conceivable pathway by which contaminants in the landfill site could migrate to and affect the quality of the water in the pipelines either during the period when the pipes are intact or when the pipes are being repaired. Similarly there is no risk that contaminants from the landfill will enter the bedding around the pipes and result in contamination of surface water or groundwater quality elsewhere.

8.14 An assessment has been carried out of the access requirements should it be necessary to repair the pipes. While the potential for leaks is low and for failures is extremely low and therefore the probability that repairs will need to be carried out also is low it is accepted that the standoff provided either side of the water pipes needs to allow for access to and repair of the pipes if it becomes necessary. The estimates for the space needed, depending on the assumptions made and the flexibility allowed for in locating the plant and items required, range from 8.5m to 20m to the side of each pipe.

8.15 It is concluded that there is no justification for the concern that following catastrophic failure of the pipe the flow of water would inundate the pipeline route and restrict access for repairs as a result of the presence of deep water. Water will drain readily from the area and is unlikely to pond in the area of the pipelines.

8.16 It is clear that the standoff distances needed for access for repairs is the limiting factor (ie the greatest distance) to determine the standoff from the water pipes. This is because the risk assessments demonstrate that the calculated crater diameter following a catastrophic failure event and the standoff distance needed so that there is no effect from the landfill activities on the structural integrity of the pipes are less (ie shorter) than the distance identified as necessary for repair access purposes. As stated above, the estimates for the space needed for access range from 8.5m to 20m to the side of each pipe therefore 20m is the maximum that is likely to be necessary.

8.17 The standoff to be agreed finally with Anglian Water will depend on their engagement on the findings of the risk assessments. It is considered that the maximum distance of 20m to the side of each pipeline should more than satisfy their concerns although it may be possible to agree a narrower allowance following their review of the risk assessments.

8.18 Water mains are routinely installed in far less accessible and more constrained locations in particular along main roads and high streets or through industrial areas on a regular basis. A finally agreed standoff either side of the pipes will allow both access for repairs (major or minor) and protection of the pipes from any effects of the proposed development. The mains will continue to be accessible at all times.

8.19 It is concluded that the location of the diverted electricity cable could be located wholly or partly outside the finally agreed standoff from the northern water pipe.

TABLES

Table PRA1

Scoping table of hazards and risks to be assessed.

The situations for which the hazards and risks need to be assessed are set out in the table below. The hazards and risks are divided into the following categories:

- physical/structural safety concerns under normal circumstances,
- physical/structural safety concerns under abnormal circumstances (ie following pipe failure rather than as a result of a small leak),
- access needs under normal circumstances,
- access needs under abnormal circumstances (ie following pipe failure rather than as a result of a small leak),
- contamination concerns/access under normal circumstances, and what potential exposure pathway is of concern
- contamination concerns/access under abnormal circumstances (ie following pipe failure), and what potential exposure pathway is of concern.

Each scenario is considered for each of the following development stages (as shown on Figure PRA2)):

A. Pre-development;
B. Operational excavation and construction stage;
C. Operational waste placement (below ground) stage;
D. Operational waste placement (above ground) stage; and
E. Post restoration period.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
A. Pre-development. **Current situation – agricultural field, 15m to 20m from the excavation boundary of the**	Pipe intact	*Physical/structural safety concerns*: Presence of water in the bedding surrounding the pipeline causing corrosion	Reduced life of the pipeline
		Access needs: Ease of access to carry out repair.	Flooding of the area with water prior to cutting off the flow.
		Contamination concerns:	No assessment needed.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
current landfill site, passing beneath nearby road. ***These scenarios represent the pre-development, baseline situation.***		None envisaged.	
	Failed pipe – assume catastrophic failure.	*Physical/structural safety concerns*: Crater formed.	What would the crater size be? Erosion of adjacent land by the water from the pipe.
		Access needs: Ease of access to carry out repair.	Flooding of the area with water prior to cutting off the flow.
		Contamination concerns: Effect on water quality at the point of supply.	Potential for silt and/or contaminants (fertiliser, pesticides, waste in existing landfill) to enter the pipe (this would be during repair works as there would be no flow following pipe failure)
B. Operational excavation and construction stage. Excavation of the adjacent phases and construction of the engineered containment liner	Pipe intact	*Physical/structural safety concerns*: Instability/movement/reduction in strength of the supporting ground Slip in the excavated slope. Presence of water in the bedding surrounding the pipeline causing corrosion	Potential to destabilise/damage the pipes. Increased risk of pipe failure. Consider the effects if excavations take place concurrently on both sides of the pipe corridor. Reduced life of the pipeline.
		Access needs: Ease of access to carry out repair.	The excavation might affect the topographical falls around the pipeline therefore resulting in a decrease in surface water runoff across the pipeline and flooding restricting access to the area to carry out repair.
		Contamination concerns:	No assessment needed.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
		No additional sources envisaged as no sources as a result of the development.	
	Failed pipe – assume catastrophic failure.	*Physical/structural safety concerns*: Crater formed.	What would the crater size be? Potential for damage to the excavated slope as a result of the crater. Potential for damage to the excavated slope as a result of the water runoff from the pipe. Potential for water from the pipe to enter the excavation.
		Access needs: Ease of access to carry out repair.	Restriction on physical space (as a result of the presence of the excavations) to carry out the pipe repair in a timely manner. The excavation might affect the topographical falls around the pipeline therefore resulting in a decrease in surface water runoff across the pipeline and flooding restricting access to the area to carry out repair
		Contamination concerns: No additional sources envisaged as no sources as a result of the development	Potential for silt and/or agricultural contaminants (fertiliser, pesticides, waste in existing landfill) to enter the pipe (this would be during repair works as there would be no flow following pipe failure)
C. Operational waste placement	Pipe intact	*Physical/structural safety concerns*: Instability/reduction in strength of the supporting ground.	Potential to destabilise/damage the pipes. Increased risk of pipe failure.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
(below ground) stage Placement of waste in the adjacent phases to levels below the ground		Slip in the excavated slope and/or supporting waste slope. Presence of water in the bedding surrounding the pipeline causing corrosion	Consider the effects if excavations and waste placement take place concurrently on both sides of the pipe corridor. Reduced life of the pipeline.
		Access needs: Ease of access to carry out repair.	Restriction on physical space (as a result of the presence of the landfill) to carry out the pipe repair in a timely manner. The landfill might affect the topographical falls around the pipeline therefore resulting in a decrease in surface water runoff across the pipeline and flooding restricting access to the area to carry out repair.
		Contamination concerns: Migration of contaminants from the waste into the water in the pipe. Migration of contaminants from the waste into the pipe bedding and onward migration to groundwater or surface water.	Assess the risks from contaminants to include gas/vapour, waste particles washed off the deposited waste mass, chemical and radioactive contaminants in leachate, LLW potential to irradiate the water in the pipes.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
	Failed pipe – assume catastrophic failure.	*Physical/structural safety concerns*: Crater formed.	What would the crater size be? Potential for damage to the excavated and lined slope as a result of the crater. Potential for damage to the excavated and lined slope as a result of the water runoff from the pipe. Potential for water from the pipe to enter the waste and generate excess leachate.
		Access needs: Ease of access to carry out repair.	Restriction on physical space (as a result of the presence of the landfill) to carry out the pipe repair in a timely manner. The landfill might affect the topographical falls around the pipeline therefore resulting in a decrease in surface water runoff across the pipeline and flooding restricting access to the area to carry out repair.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
		Contamination concerns: Effect on water quality at the point of supply. Potential for contaminants in the waste to escape as a result of the damaged containment and migrate.	Potential for contaminants from the waste or leachate to enter the pipe (this would be during repair works as there would be no flow following pipe failure). Potential for contaminants from the waste or leachate to escape as a result of the damaged containment and migrate to the air, surface water or groundwater. Assessment of the risks from contaminants to include gas/vapour, waste particles washed off the deposited waste mass, chemical and radioactive contaminants in leachate.
D. Operational waste placement (above ground) stage Placement of waste in the adjacent phases to levels above the ground	Pipe intact	*Physical/structural safety concerns*: Instability/reduction in strength of the supporting ground. Slip in the above ground waste slope. Presence of water in the bedding surrounding the pipeline causing corrosion. Erosion as a result of water runoff from the filled waste areas.	Potential to destabilise/damage the pipes. Increased risk of pipe failure. Consider the effects if waste placement take place concurrently on both sides of the pipe corridor. Reduced life of the pipeline.
		Access needs: Ease of access to carry out repair.	Restriction on physical space (as a result of the presence of the landfill) to carry out the pipe repair in a timely manner. The landfill might affect the topographical falls around the pipeline therefore resulting in a

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
			decrease in surface water runoff across the pipeline and flooding restricting access to the area to carry out repair.
		Contamination concerns: Migration of contaminants from the waste into the water in the pipe. Migration of contaminants from the waste into the pipe bedding and onward migration to groundwater or surface water.	Assess the risks from contaminants to include gas/vapour, waste particles washed off the deposited waste mass, chemical and radioactive contaminants in leachate, LLW potential to irradiate the water in the pipes.
	Failed pipe – assume catastrophic failure.	*Physical/structural safety concerns*: Crater formed.	What would the crater size be? Potential for damage to the lined slope and placed waste as a result of the crater. Potential for damage to the lined slope and placed waste as a result of the water runoff from the pipe. Potential for water from the pipe to enter the waste and generate excess leachate.
		Access needs: Ease of access to carry out repair.	Flooding restricting access to the area to carry out repair. Restriction on physical space (as a result of the presence of the landfill areas) to carry out the pipe repair in a timely manner.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
		Contamination concerns: Effect on water quality at the point of supply. Potential for contaminants in the waste to escape as a result of the damaged containment and migrate.	Potential for contaminants from the waste or leachate to enter the pipe (this would be during repair works as there would be no flow following pipe failure). Potential for contaminants from the waste or leachate to escape as a result of the damaged containment and migrate to the air, surface water or groundwater. Assessment of the risks from contaminants to include gas/vapour, waste particles washed off the deposited waste mass, chemical and radioactive contaminants in leachate.
E. Post restoration period After capping and restoration of the site	Pipe intact	*Physical/structural safety concerns*: Instability/reduction in strength of the supporting ground. Slip in the above ground restored site slope. Presence of water in the bedding surrounding the pipeline causing corrosion. Erosion as a result of water runoff from the restored landfill areas.	Potential to destabilise/damage the pipes. Increased risk of pipe failure. Reduced life of the pipeline.
		Access needs: Ease of access to carry out repair.	Restriction on physical space (as a result of the presence of the landfill) to carry out the pipe repair in a timely manner. The landfill might affect the topographical falls around the pipeline therefore resulting in a

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
*The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.			
			decrease in surface water runoff across the pipeline and flooding restricting access to the area to carry out repair.
		Contamination concerns: Migration of contaminants from the waste into the water in the pipe. Migration of contaminants from the waste into the pipe bedding and onward migration to groundwater or surface water.	Assess the risks from contaminants to include gas/vapour, chemical and radioactive contaminants in leachate, LLW potential to irradiate the water in the pipes.
	Failed pipe – assume catastrophic failure.	*Physical/structural safety concerns*: Crater formed.	What would the crater size be? Potential for damage to the capped and restored slope or lined perimeter as a result of the crater. Potential for damage to the capped and restored slope or lined perimeter as a result of the water runoff from the pipe. Potential for water from the pipe to enter the waste and generate excess leachate. Flooding restricting access to the area to carry out repair. Restriction on physical space (as a result of the presence of the landfill areas) to carry out the pipe repair in a timely manner.
		Access needs: Ease of access to carry out repair.	Flooding restricting access to the area to carry out repair.

Development stage	Status of the water pipe(s)*	Hazards and risks to be assessed	Potential consequences to be assessed
**The risks and consequences will be considered with respect to one pipe and to both pipes at the same time where this affects the consequences.*			
			Restriction on physical space (as a result of the presence of the landfill areas) to carry out the pipe repair in a timely manner.
		Contamination concerns: Effect on water quality at the point of supply. Potential for contaminants in the waste to escape as a result of the damaged containment and migrate.	Potential for contaminants from the waste or leachate to enter the pipe (this would be during repair works as there would be no flow following pipe failure). Potential for contaminants from the waste or leachate to escape as a result of the damaged containment and migrate to the air, surface water or groundwater. Assessment of the risks from contaminants to include gas/vapour, waste particles washed off the deposited waste mass, chemical and radioactive contaminants in leachate.

Table PRA2

Assessments carried out to address the key risk scenarios

Relevant stage of development (See Table PRA1)	**Management controls which are available and can be implemented**	**Assessments carried out**	**Conclusions**
1. Pipe Intact and Pipe Failed: Access for maintenance and repairs			
All stages	Distance of standoff of landfill operations and any ground structures such as hedges and fences. It is considered that the provision of laydown and stockpile areas does not need to be accommodated within the standoff area as an agricultural field with an access track is available at the eastern end of the pipe route.	Assessed in Section 1 of the report. Review of operational requirements for access to effect repairs. Advice has been obtained from a specialist pipeline engineer on the likely access requirements needed to facilitate a pipeline repair or replacement.	Estimates for the space needed, depending on the assumptions made and the flexibility in locating the plant and items required, range from 8.5m to 20m. The standoff distances needed for access for repairs is the limiting factor (ie the greatest distance) to determine the standoff from the water pipes as the calculated crater size following catastrophic failure and standoff needed so that there is no effect on the structural integrity of the pipes are less (ie shorter) than those identified as necessary for repair access purposes.

Relevant stage of development (See Table PRA1)	**Management controls which are available and can be implemented**	**Assessments carried out**	**Conclusions**
2. Pipe Intact: Impact on structural integrity of the pipes as a result of excavation and filling			
Stages B, C, D	<u>Proposed:</u> Distance of standoff of the excavation that does not result in significant movement of the pipeline due to changes in the stresses on the ground surrounding the pipeline during to excavation and filling of the landfill phases. The excavated slope designs are assessed to verify that they have a factor of safety of greater than 1.3 while they are open. The slopes do not stand open for long as they are lined with clay and geosynthetic materials before being backfilled soon after construction. The excavated slopes are assessed to have factors of safety of 1.4 while they are open and increase rapidly as they are lined and then filled, becoming fully supported and therefore unable to fail once waste reaches ground level. During the slope excavation and lining there is full time supervision on site of the works by independent quality assurance engineers. During the filling and restoring of the slopes the stability and integrity of the slopes and lining system are monitored by Augean in	Assessed in Section 4 of the report. Geotechnical risk assessments have been undertaken to verify the stability of the excavated and lined slopes prior to, during and following landfill cell construction and filling. Further assessment has been undertaken, in consultation with a specialist pipeline engineer, to verify that standoffs from the pipeline and pipeline joints and bends will be sufficient to prevent changes to the current stress conditions of the ground surrounding the pipeline during to excavation and filling of the landfill phases	As a result of the factors of safety incorporated into the landfill design, the CQA implemented to confirm the landfill is constructed in accordance with the design, the ongoing monitoring of the slopes in accordance with the Environmental Permit and the distance from the edge of the excavation to the pipes there is a negligible potential for the slopes of the adjacent landfill phases to fail and to result in instability of or damage to the water pipes.

Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
	accordance with the site operational procedures and environmental permit requirements. Additional: No additional controls are considered necessary.		
3. Pipe Intact: Contaminant migration from the landfill below ground to the pipeline surrounds			
Stages C, D, E	Proposed: Landfill engineering prevents the migration of contaminants beyond the site (1m clay at $1x10^{-9}$m/s permeability and 2mm HDPE $1x10^{-14}$m/s). The landfill and the pipeline are situated within in-situ clay with a vertical permeability of 1.9×10^{-10}m/s to 8.4×10^{-12}m/s with a geometric mean of 2.6×10^{-11}m/s (based on 5 samples of glacial till from the site). Leachate levels are maintained no greater than 1m above the base of the site which is at least 7m below the pipelines. Groundwater is at least 8m below the base of the site in the vicinity of the pipelines. As the wastes deposited in the landfill will have limited gas generating potential the generation of gases or vapours under pressure at the site is not anticipated. Gas concentrations and pressures are monitored under the Environmental Permit. If active	Assessed in Section 6 of the report. There is no identified below ground pathway for the contaminants to migrate to the pipelines as contaminants. Gamma radiation from LLW is attenuated through the landfill cell walls and the clay and soil. Accordingly gamma radiation from the LLW will not affect the properties of the water in the pipelines. This specific assessment will be presented in the ESC which is under preparation and will be submitted to the Environment Agency with the application to vary the LLW landfill disposal permit.	It is concluded that there is no conceivable pathway by which solid, soluble or gaseous contaminants in the landfill site could migrate to and affect the quality of the water in the pipelines.

Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
	extraction and management becomes necessary it will be implemented in accordance with the Environmental Permit. Additional: No additional controls are considered necessary.		
4. Pipe Intact: Contaminant run-off to the pipeline surrounds			
Stages C, D	Proposed: During stage C the waste is below ground level. During Stage D the edge of the waste is maintained at 1m below the top of the landfill liner. Run-off from the landfilled waste drains back into the landfill. A geocomposite drainage layer (geotextile with a drainage core) will be installed to provide a leachate drainage blanket up the inner side slopes of the engineered liner. Additional: No additional controls are considered necessary.	Assessed in Section 6 of the report. There is no identified pathway for the contaminants to migrate to the pipelines	It is concluded that there is no risk that contaminants from the landfill will enter the bedding around the pipes and result in contamination of surface water or groundwater quality elsewhere.
5. Pipe Intact: Surface water run off causing increased inundation around pipelines increasing the potential for erosion of the pipes			
Stage E	Proposed: Interception ditches will be installed along the edge of the landfills diverting water away from the pipelines. Storm attenuation areas are for short term storage after storm events and should not	Assessed in Section 4 of the report. Assessment of the surface water drainage proposals for the management of the potential run off compared with	It is considered that as a result of the surface water management controls which will be implemented there is a negligible risk that there will be increased inundation of the pipe

Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
	result in additional water inundation around the pipelines <u>Additional:</u> Water levels in the bedding around the pipelines could be monitored routinely before and after operations to determine if there is a significant change. Storm attenuation areas could be lined with clay if monitoring indicates water is draining towards the pipelines	pre-development drainage characteristics	bedding around the pipeline resulting in increased corrosion of the pipes. Monitoring of the water levels around the bedding could be carried out in the anticipated 10 years prior to landfilling near to the pipeline and following landfilling in the adjacent phases so that if additional surface water drainage management measures are identified as necessary they can be implemented.
6. Pipe Failed: Catastrophic failure resulting in a crater affecting the integrity of the landfill			
Stages C, D, E	<u>Proposed</u>: The landfill will be constructed beyond the predicted crater <u>Additional</u>: No additional controls are considered necessary.	Addressed in Section 5 of the report. Although the probability of such an occurrence is extremely low, an assessment has been carried out by a specialist pipeline engineer of the potential size of a crater or erosion zone formed as a result of a high pressure release.	There is a low probability of a leak in the pipes and an extremely low probability of a catastrophic failure of the pipes. The low risk of serious failure could be reduced further by the provision of monitoring at the site. It is agreed by Anglian

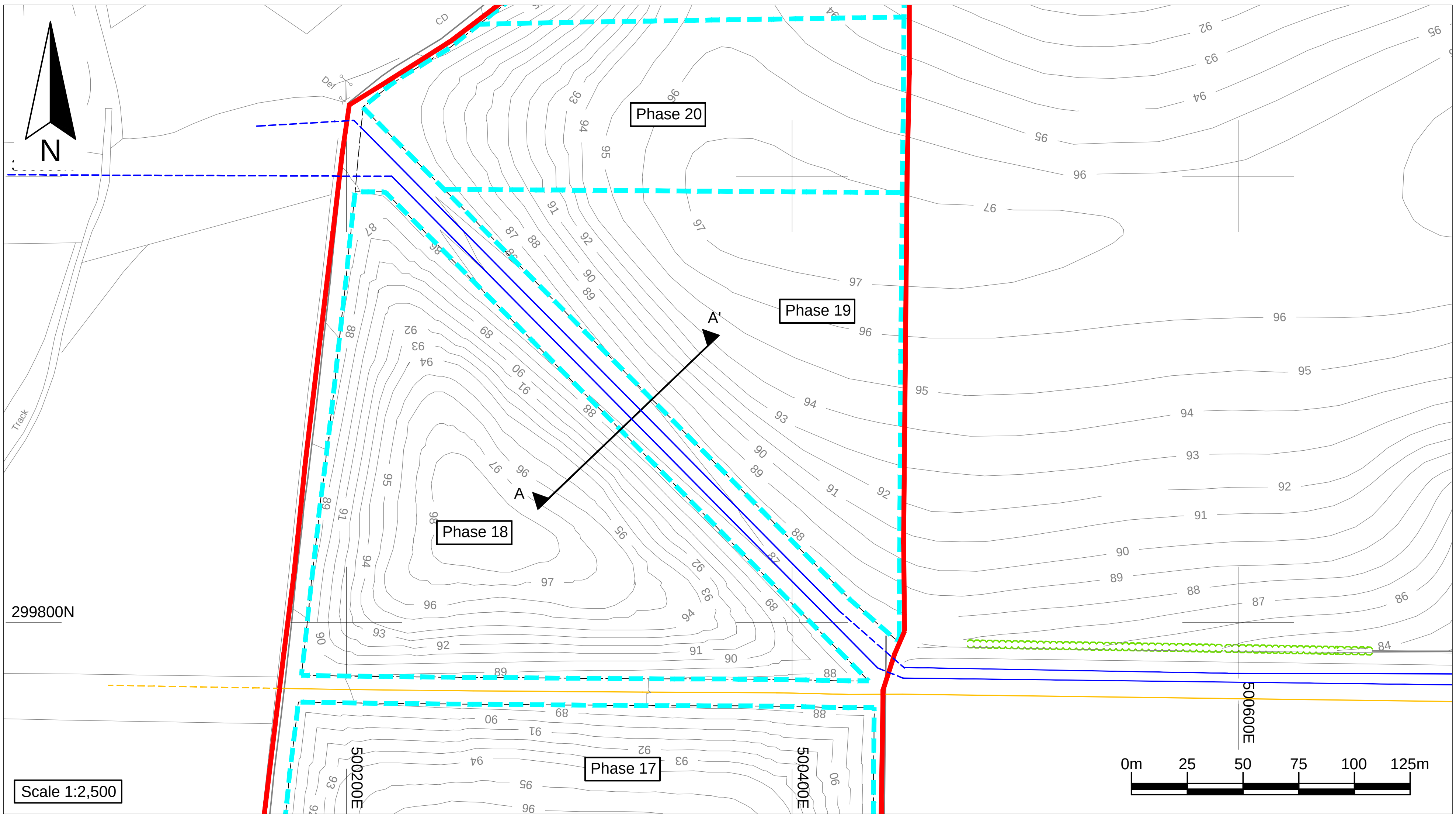
Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
			Water that monitoring (eg acoustic loggers) could provide for detection at the site of any leaks so that early attention can be paid to carrying out repairs. Early identification of faults would allow repairs to be carried out to reduce further the risk of catastrophic failure. A worst case calculation has been carried out of the area of disturbance which could be formed in the event of catastrophic failure. The calculation shows that if the worst case burial depth of the pipes is assumed (3m), the crater extends to a calculated distance to the side of each pipe of 3.41m. This worst case calculation shows that at the current design standoff distances to the landfill excavation boundary of 9.5m and to the fence line boundary of 7m, such an extremely

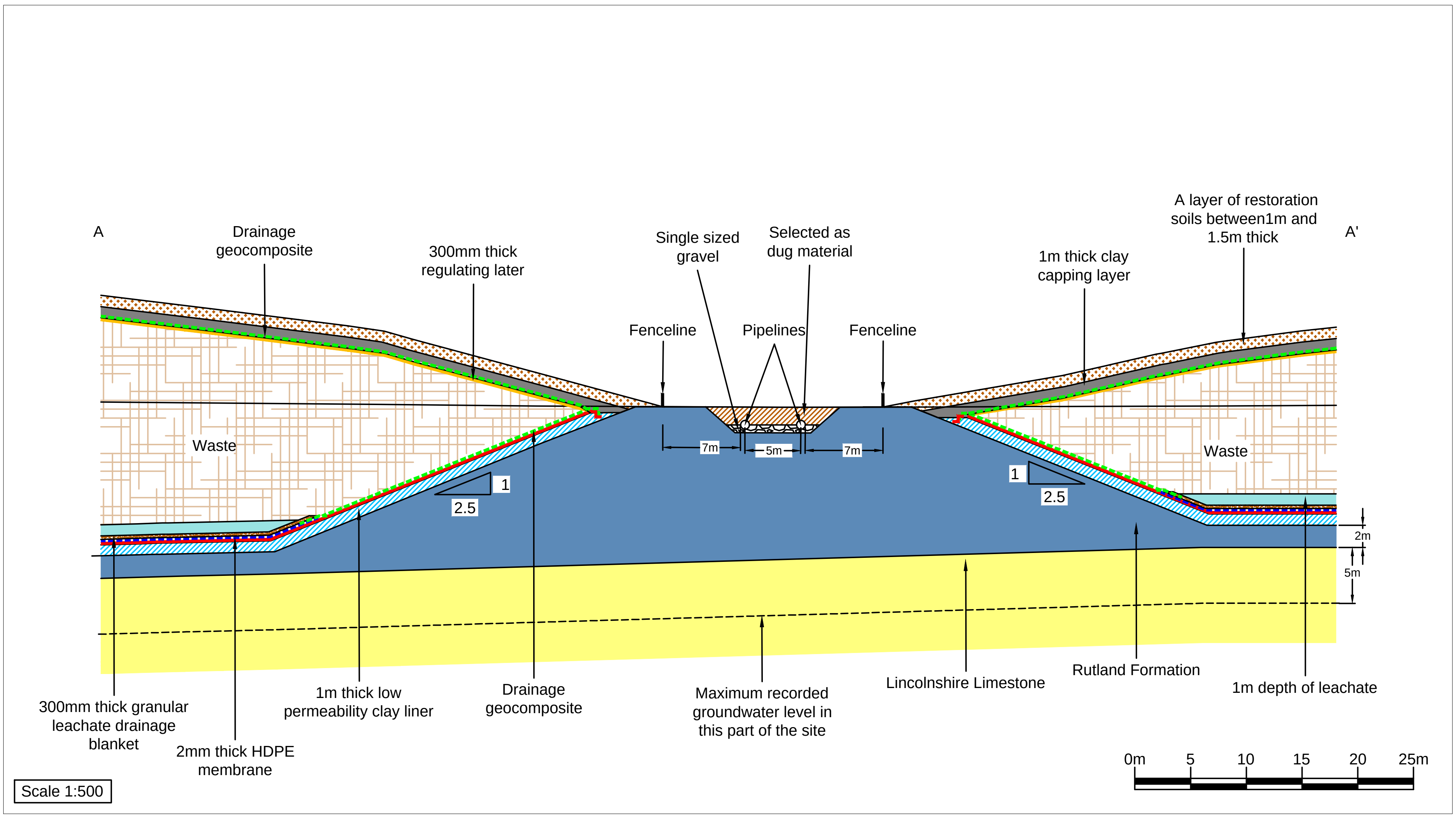
Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
			unlikely, worst case catastrophic failure would not affect the integrity of the landfill engineering. There would remain a significant buffer distance between the extent of any ground disturbance resulting from the failure and the landfill structure.
7. Pipe Failed: Failure resulting in water discharge to the landfilled waste			
Stages C, D	Proposed: The landfill would accommodate the water and would have to be managed and removed as leachate. As part of the operational surface water management drainage ditches are installed along the outside of the operational areas to divert surface water runoff away from the landfill areas. Additional options: Consider the installation of leak detection systems to provide early warning of leaks so that repairs can be	Assessed in Section 5 of the report. The volume of water that would be discharged to the landfill in the event of complete pipe failure has been calculated.	As for scenario 6 above, the low risk of serious failure could be reduced further by the provision of monitoring at the site. It is agreed by Anglian Water that monitoring (eg acoustic loggers) could provide for detection at the site of any leaks so that early attention can be paid to carrying out repairs. Early identification of faults would allow repairs to be carried out to reduce further the risk of catastrophic failure

Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
	carried out well before any approach to catastrophic failure. In addition to the drainage ditches, bunds could be constructed along the edge of the void during the operational period to divert water away from the waste.		hence release of significant volumes of water. Calculations show that in the unlikely event of the discharge of all the water from both pipes directly into the landfill void the increase in leachate volume is manageable and would be contained within the engineered containment system. The short term increase would not pose an increase in the environmental risk as the excess depth of leachate would be present only for a relatively short time prior to removal.
8. Pipe Failed: Failure resulting in water inundation along the pipeline area preventing access			
Stages C, D, E	Falls are generally along the line of the pipeline and fall to the north west for the majority of the pipeline area, with the south eastern third falling to the south east. Water is unlikely to pond in the area of the pipeline.	Assessed in Section 7 of the report. The surface water management system for the restored site is designed to retain the current, pre-development, patterns of drainage and this includes the drainage patterns along the pipeline route.	It is concluded that water is unlikely to pond in the area of the pipelines. If there remains any justified concern, ditches can be installed at the edges of the pipe corridor

Relevant stage of development (See Table PRA1)	Management controls which are available and can be implemented	Assessments carried out	Conclusions
			to provide confidence regarding effective drainage.
9. Pipe Failed: Risk of contamination of surrounding ground will enter the water supply			
Stages C, D, E	As a result of the measures that will be implemented to minimise the risks addressed above, there is no risk that contaminants will enter the pipeline during pipeline repairs as the ground around the pipeline will not contain contaminants from the landfill.	Assessed in Section 6 of the report. An assessment has been carried out of the risk of contamination of water in the pipes during repair of the pipes.	It is concluded that there is no conceivable pathway by which solid, soluble or gaseous contaminants in the landfill site could migrate to and affect the quality of the water in the pipelines.

FIGURES





Key / Notes

Proposed western extension to the ENRMF hazardous waste landfill Environmental Permit

Approximate phase boundary in the proposed Western Extension

Cross section location

Water main taken from Service information from drawing number 2603.SWM.02C dated 24 September 2007 provided by Egniol Limited

Approximate location of the gas pipeline extrapolated from the topographical survey information

Gas pipeline

Top of Bank

Top of Ditch

Contours (mAOD)

Notes:
Drawing based on LSS models references AU-KCW-15872.LSS, MARCH21_ENRMF_FINAL RESTORATION LANDFORM_SCENARIO 1B provided by DB Landscape Consultancy on 1 March 2021, AU-US-16318.LSS, AU-KCW-15984.LSS, AU-KCW-15987.LSS and AU-KCW-15990.LSS.

Rev	Status	Drn	App	Chk	Date
	Final	KR	SPS	LH	16/06/22

Site
EAST NORTHANTS RESOURCE MANAGEMENT FACILITY

Client
Augean SOUTH LTD

Title
Cross section showing the proposed landfill operations in the vicinity of the water pipelines in the proposed western extension

Figure PRA 1

Scale
As shown@A3

Drawing Ref
AU/KCW/05-22/23129

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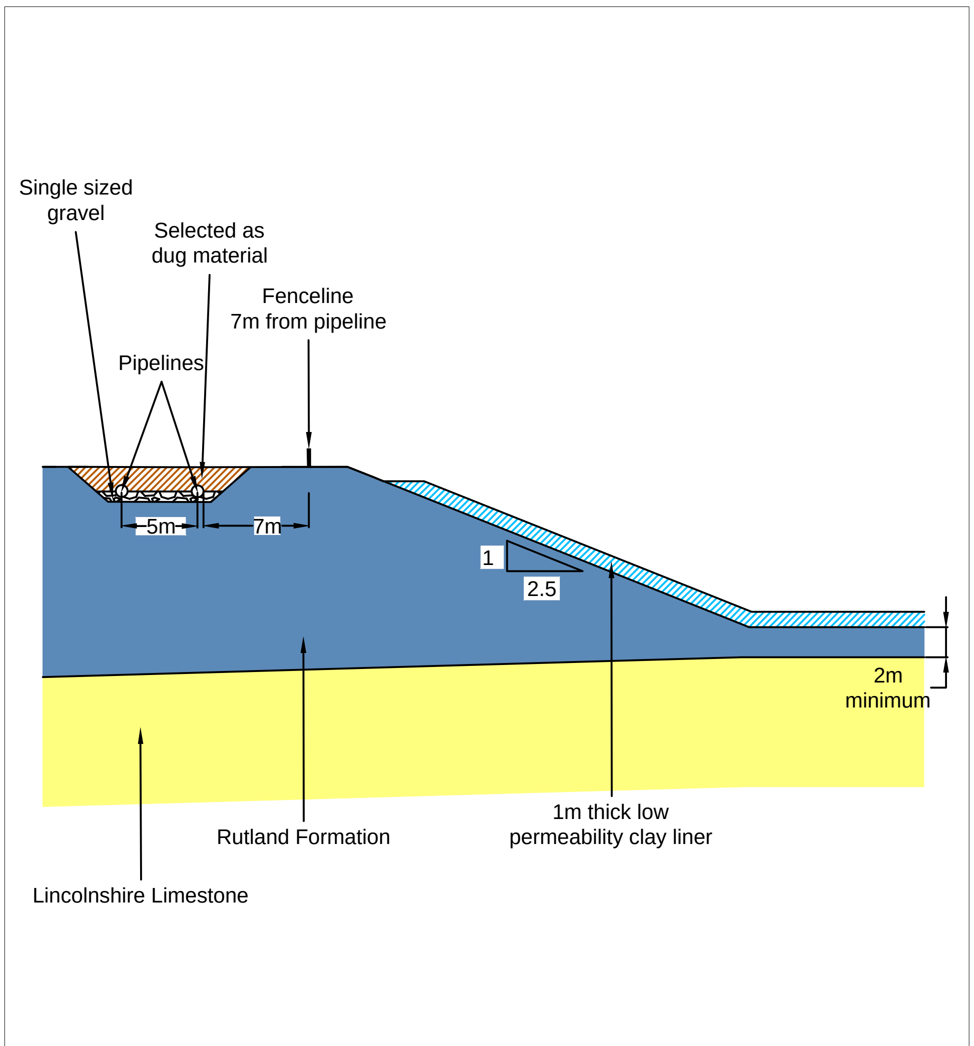
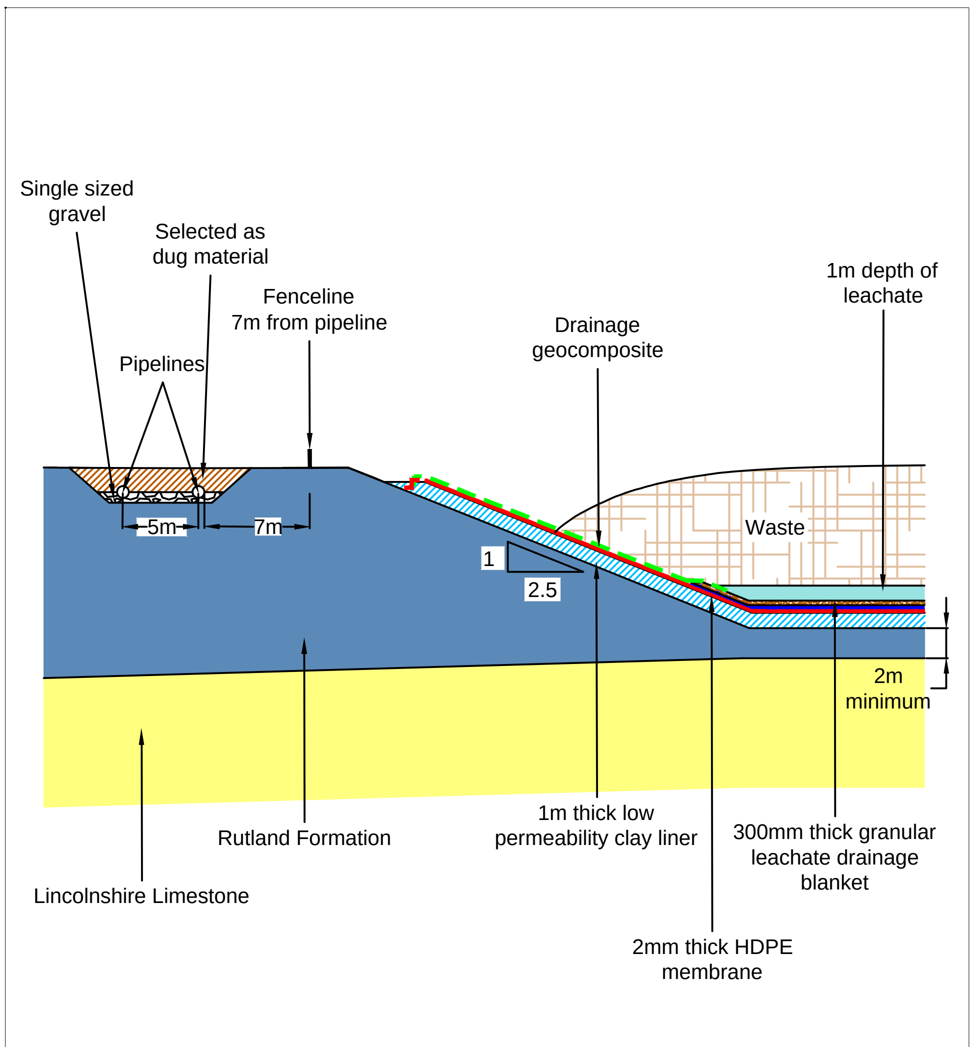
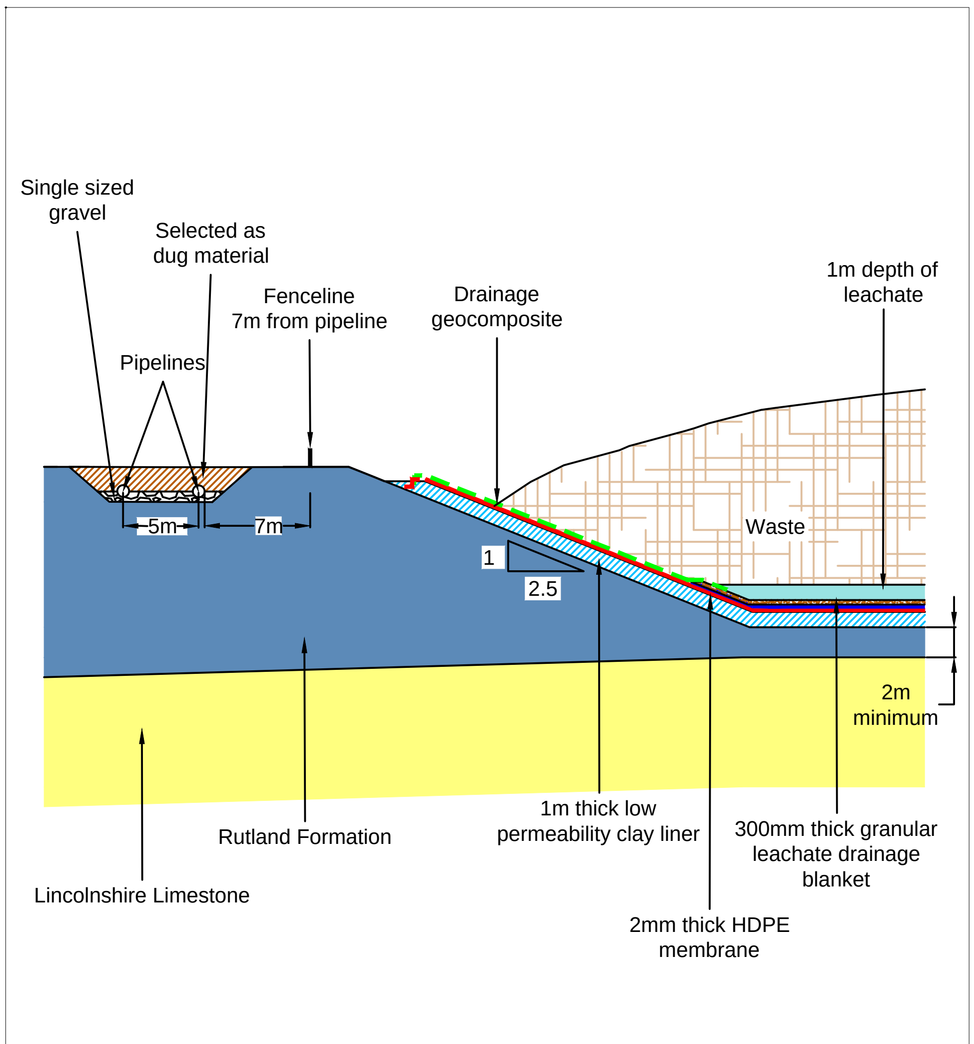


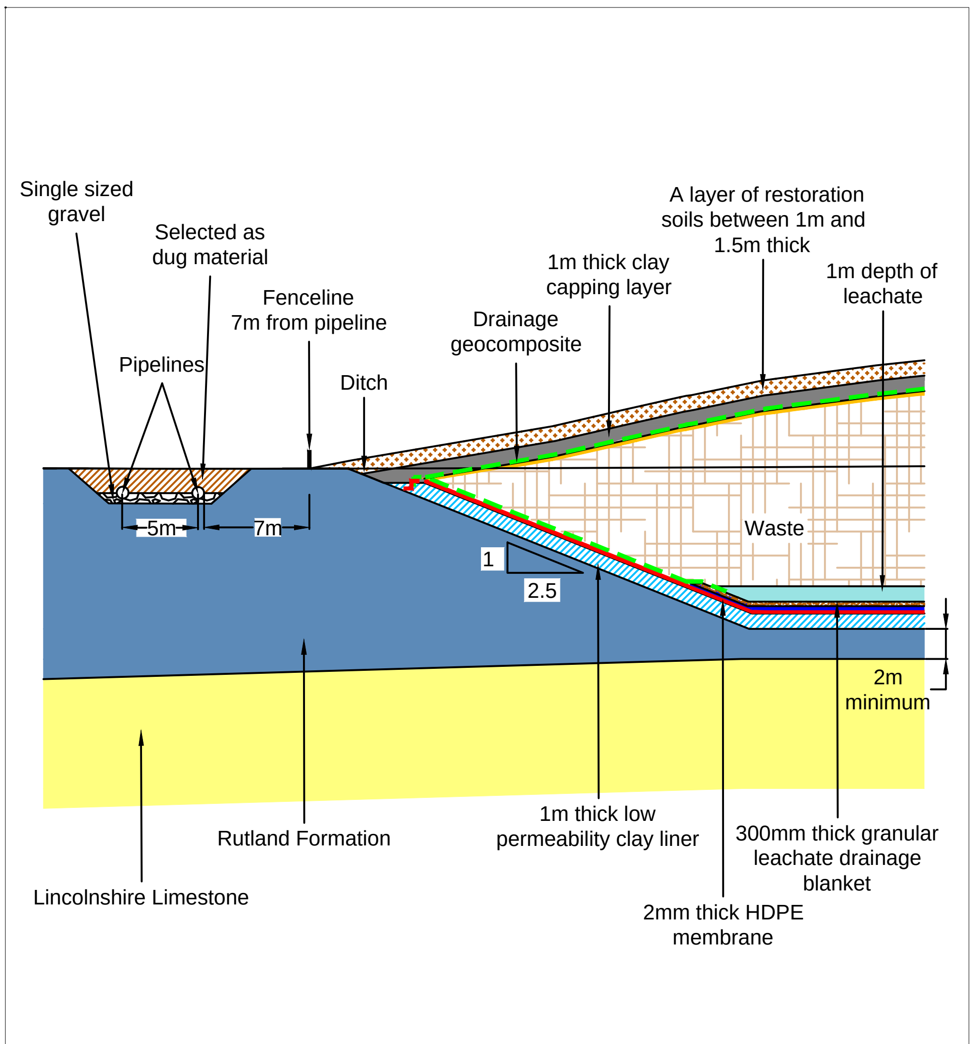
B. Operational excavation and construction stage



C. Operational waste placement (below ground) stage



D. Operational waste placement (above ground) stage



E. Post restoration period

Key / Notes

Rev	Status	Drn	App	Chk	Date
	Final	KR	SPS	LH	16/06/22

Site
EAST NORTHANTS RESOURCE MANAGEMENT FACILITY

Client
Augean SOUTH LTD

Title
Schematic cross sections through the stages of landfill development

Figure PRA 2

Scale
1:500@A3

Drawing Ref
AU/KCW/06-22/23193

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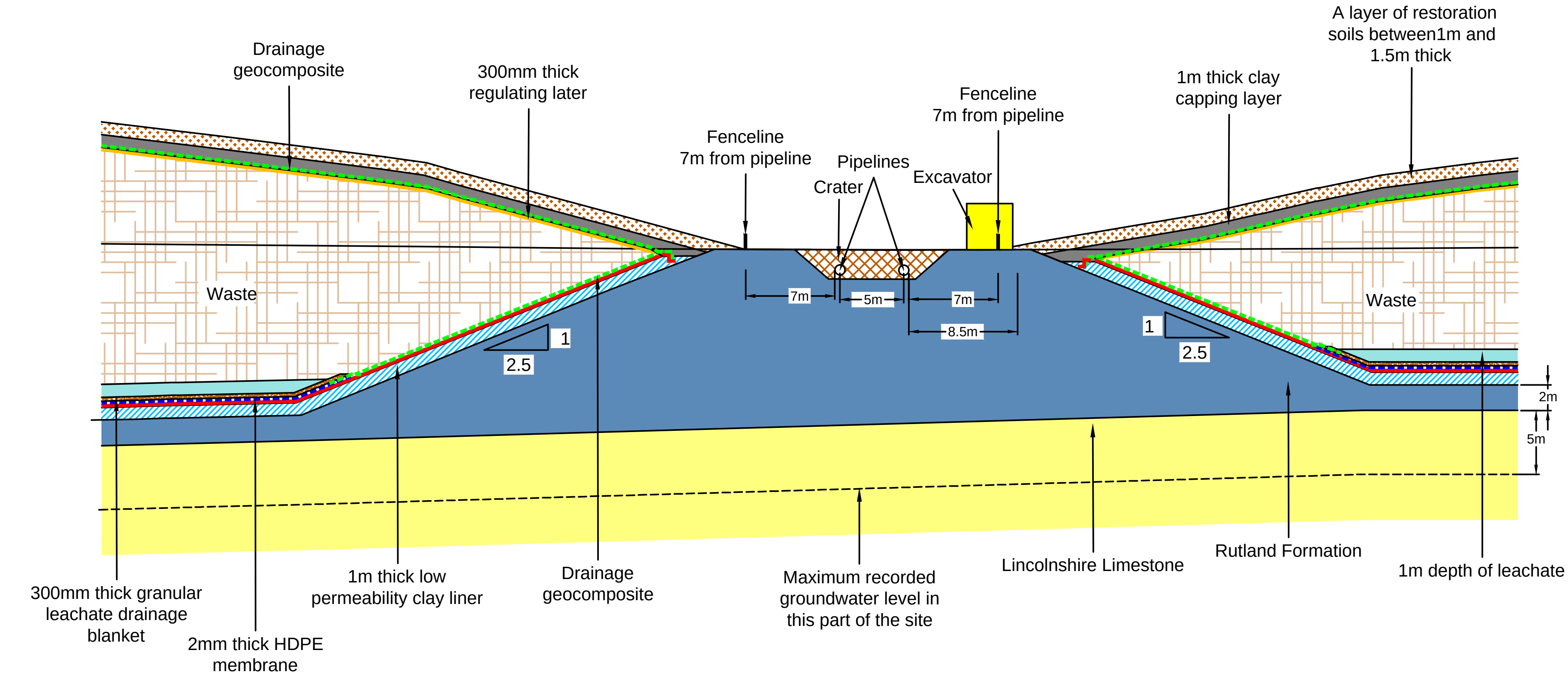
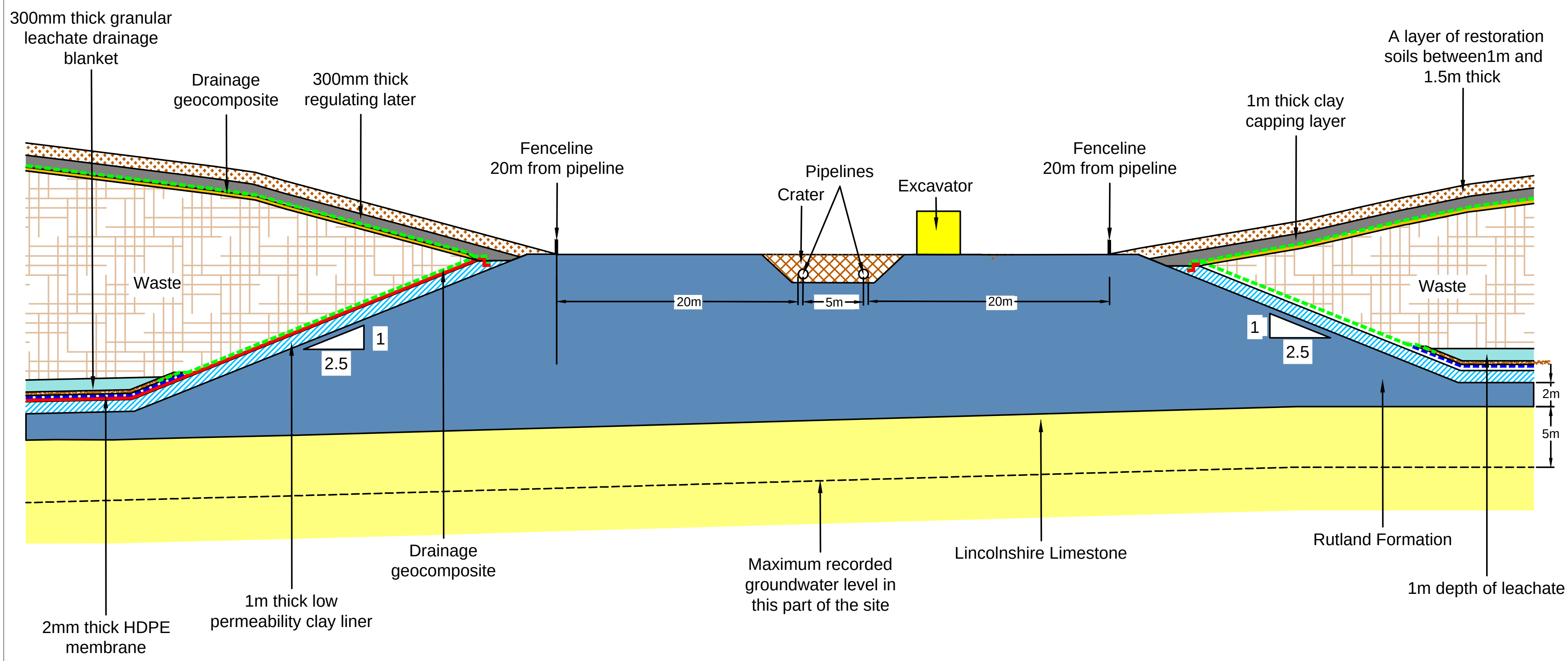
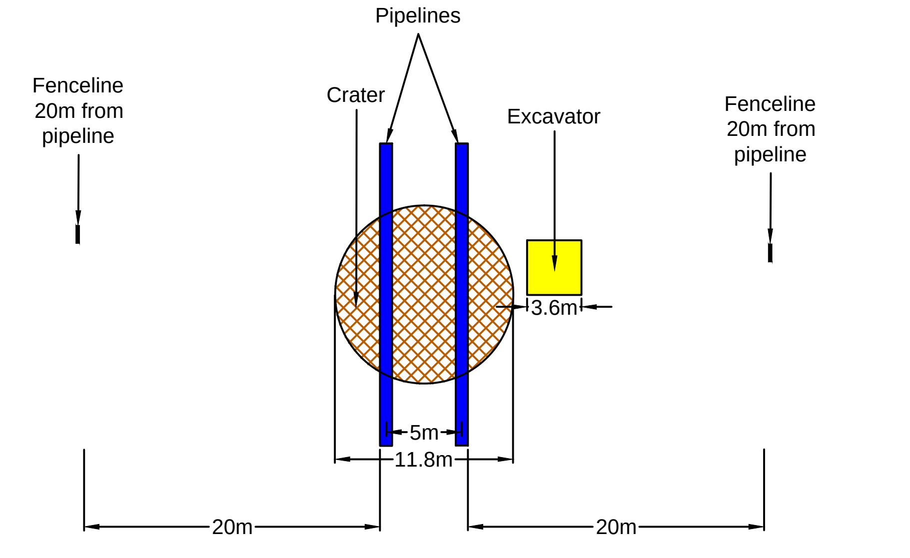
7m standoff from pipeline to the fence



20m standoff from pipeline to the fence



Birds eye view/plan view



Key / Notes

0m 5 10 15 20 25m

Rev	Status	Drn	App	Chk	Date
	Final	KR	SPS	LH	16/06/22

Site
EAST NORTHANTS RESOURCE MANAGEMENT FACILITY

Client
Augean SOUTH LTD

Title
Schematic drawing showing access for Anglian Water pipeline maintenance/replacement works

Figure PRA 3

Scale
1:500@A3

Drawing Ref
AU/KCW/05-22/23173

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APPENDIX PRA 1

APPENDIX PRA1 FLOW CAPACITY CALCULATIONS IN THE PIPELINE CORRIDOR

Table PRA A - Calculations of the conveyancing capacity of the pipeline corridor using the Manning Resistance Equation

Parameter	Value	Unit	Justification
Flow of water from burst pipe	1	m^3/s	Provided by Anglian Water
Elevation of pipeline corridor bed at upstream end	87.69	mAOD	The elevation of the current topography along south western boundary of the pipeline corridor ~3/4 of the way along the corriodor (NW to SE)
Elevation of pipeline corridor bed at downstream end	85.39	mAOD	The elevation of the current topography along north eastern boundary of the pipeline corridor in NW of corridor
Length of pipeline corridor	200	m	Distance between 2 points above along the corridor
Manning's roughness coefficient	0.107		Calculated based on Manning's in Table PRA B
Bed width	25.6	m	Corridor width - total easement width included in the application design (between the fence lines) of 14m plus the distance between the 2 pipes and the width of the pipes which is a total of 20.6m. An additional distance of 2.5m each side is included from the fence line to the excavation boundary for the landfill cells giving a total easement width of 25.6m.
Depth of flow	0.14	m	The average depth of the channel - assumed depth of water
Channel area	3.671318	m^2	Calculated.
Wetted perimeter	25.89	m	Calculated.
Hydraulic radius	0.14		Calculated.
Gradient	0.0115		Calculated.
Discharge	1.00	m^3/s	Calculated using the Manning Resistance Equation as presented in Reference 1
Discharge	1000	l/s	Calculated.

References

Reference 1. Highways Agency. February 2004. Drainage of runoff from natural catchments. Design manual for roads and bridges, Volume 4, Section 2, Part 1. Report reference HA 106/04

Denotes parameters which are determined based on the restoration scheme
Denotes parameters which are calculated based on other parameters
Denotes parmeters which are specified to achieve the necessary flow in the ditch

Table PRA B - Calculation of Manning's Roughness Coefficient, n

$n = (n_b + n_1 + n_2 + n_3 + n_4)m$

Pipeline corridor			
Parameter	**Symbol**	**Corridor w**	**Justification**
Base value	n_b	0.032	Upper end of values for straight uniform channel in Firm Soil (ie clay material).
Irregularity of the channel	n_1	0.005	Upper end of minor iregularities.
Cross section	n_2	0.005	Size and shape of channel does not change significantly. This is the upper end of the alternating occasionally category.
Obstructions	n_3	0.015	Upper end of minor obstructions category.
Vegetation	n_4	0.05	Upper end of large category.
Meandering	m	1	No significant meandering
	n	0.107	

References

Reference 1. United States Geological Survey. 1989. Guide for Selecting Manning's Roughness Coefficients for Natural Catchments and Floodplains. United States Geological Survey Water-Supply Paper